Appendix

Benefit-Cost Analysis Methodology Technical Memorandum

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CONGESTION RELIEF ANALYSIS
BENEFIT-COST ANALYSIS METHODOLOGY
TECHNICAL MEMORANDUM
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Introduction

What's the Purpose of this Report?

The purpose of this report is to document the benefit-cost analysis methodology and process for the WSDOT Congestion Relief Study. The 2003 state Legislature directed WSDOT to conduct a study of regional congestion relief solutions for Puget Sound, Spokane, and Vancouver. It requires that "The study must include proposals to alleviate congestion consistent with population and land use expectations under the Growth Management Act, and must include measurement of all modes of transportation" (ESHB 1163 Sec. 222(3)). The scope of work for this study includes a benefit-cost analysis, the results of which become one of the study's performance measures.

The report is organized as follows:

- Overview of Approach
- Benefit Assessment Methodology
- Evaluating Economic Feasibility

Overview of Approach

Why Benefit-Cost Analysis?

The purpose of this study's benefit-cost analysis is two-fold. First, the benefit-cost analysis will identify which portfolios of projects — as represented by the "focused" and "mixed" scenarios — show some likelihood of economic feasibility based upon those benefits and costs which are quantifiable. Secondly, this analysis will enable comparisons to be drawn between the various scenarios or portfolios of projects.

Benefit-cost analysis compares the incremental or additional user and social benefits provided by a particular alternative's proposed capital investments with the incremental costs of implementing and maintaining that alternative, relative to the basis of comparison or "baseline" alternative.

The assessment of economic feasibility must assume a timeframe for the accrual of benefits and costs. Typically, benefits are assumed to accrue over a number of years (e.g., 20 to 30 years plus the duration of construction), while the capital plus operations and maintenance (O&M) costs are incurred over the same period. Alternatively, annual benefits in some future year can be compared to the annual equivalent lease payment for the capital investment plus annual O&M costs. In either case, present value discounting via a real discount rate is used to increasingly reduce the magnitude of benefits and costs over time. This reflects a "premium" or preference for present access to a resource over future consumption, all else equal. Alternatives that generate ***net*** benefits, in which benefits exceed costs in present value terms relative to the baseline, are considered "economically feasible".

Defining Benefits, Costs, and Benefit-Cost Evaluation Measures

The various conceptual portfolios of projects considered in this study are referred to as "scenarios" rather than alternatives. These scenarios have not been developed to adhere to any particular budget constraint or uniform cost target, and their associated capital investment and ongoing costs would likely vary substantially. Moreover, there is considerable variability in the level of detail and precision of the costs estimates associated with different scenarios. In fact, both benefits and costs are to be estimated as ranges rather than single values. In addition, there will likely be interest in how the "mixed scenarios" or combinations of investments score in terms of economic feasibility and compare with each other without further determination of whether or not they are financially feasible.

Given these conditions, and in particular the ranges applied to the benefits and costs of the scenarios, it was decided not to report the typical benefit-cost evaluation measures.

Originally, there was interest in presenting the net present value (NPV) and not the benefit-cost ratio (B/C). The B/C ratio is the sum of all incremental benefits in present value terms (PVB) divided by the present value of all incremental costs (PVC): B/C = PVB / PVC. The B/C ratio measures the power or factor by which evaluation period benefits exceed costs, with values greater than one representing economically feasible options. The B/C ratio was disregarded for a variety of reasons, not the least of which is that this study is not about prioritizing or ranking projects/portfolios of projects with the intent to decide how to best allocate an established capital budget — which is a primary use of B/C ratios.

NPV is simply the sum of all incremental benefits in present value terms (PVB), less the present value of all incremental costs (PVC): NPV = PVB – PVC. Under this criterion, a scenario with an NPV greater than zero may be considered "economically feasible". A scenario with a negative NPV may still generate significant benefits; however, the quantified benefits in present value terms do not exceed the identified public sector costs for implementing and maintaining the improvements associated with the scenario in question.

Instead, the component pieces of both the NPV and the B/C ratio will be reported, expressed as ranges. The present value of all incremental benefits (PVB) and the present value of associated project costs (PVC) will be conveyed as ranges with minimum, maximum, and expected central values.

It is important to recognize different interpretations that can be drawn by looking at the reported PVB, PVC, and the NPV and the B/C ratio evaluation criteria that may be derived from them. This is especially true when scenarios are of different magnitudes or scale, as is the case in this study. A smaller scale scenario may have a relatively high B/C ratio, but generate a NPV that is lower than some other larger scale scenario. For example, consider the case of a single project that generates $9.0 M of PVB for $1.0 M of PVC. The B/C ratio would be a relatively high 9.0, but the NPV would be only $8.0 M. On the other hand, a larger scale project may have tremendous gross and net benefits but also larger scale costs that render a less robust B/C ratio. For example, consider a project that generates $1.0 B of PVB for a PVC of $900 M. The B/C ratio would be only 1.1, but the NPV would be $100 M. In this case, the small project would appear to be the most economically feasible from the B/C ratio criterion, but the large project would appear to be the most economically feasible from the NPV criterion.

As previously noted, the B/C ratio can be useful for ranking or prioritizing a list of potential projects that are subject to a budget or funding constraint, particularly when the "cost" denominator is limited to the public sector (government) costs of capital implementation and ongoing O&M costs of each alternative, relative to the baseline. However, in the context of this study, the B/C ratio could be misleading when evaluating alternatives of different magnitudes or types, especially in the assumed budget-unconstrained environment. Though B/C ratios will not be reported, benefits and costs are identified and grouped in a manner that would be consistent with calculating B/C ratios, insofar as costs are defined as only those public sector expenditures on the capital implementation and ongoing O&M activities of each alternative relative to the baseline. All other impacts are defined as benefits, where "cost" impacts are handled as disbenefits (negative benefits) to users or society as a whole.

Congestion Relief Analysis Perspective

To facilitate analysis of the multi-project scenarios of this study, it is assumed that multiple projects would be implemented simultaneously over an entire region. This poses some unique challenges not typically encountered when evaluating a single project or improvements within a single corridor. Travel behavior changes resulting from system-wide improvements are more complex and difficult to model. Impacts of one improvement elsewhere in the system cannot be ignored, and the impacts of value pricing will be much more complex when applied universally versus locally. Given that the projects being evaluated are largely at the conceptual level, cost estimation, both capital and ongoing operations and maintenance, becomes a much more daunting exercise. Similarly, broad assumptions need to be made regarding the time required to construct these projects.

As a result of the scale of this study, in terms of the complexity of the portfolios of projects, the number of projects, and the conceptual nature of these project, the approach for evaluating economic feasibility for this project is somewhat different than it would typically be for a single project/corridor. Departures from the "norm" and/or the application of simplifying assumptions are noted herein.

General Objectives

The objective of this report is to outline the methodology for evaluating and comparing the economic feasibility of the "focused" and "mixed" scenarios, relative to a single minimal action/ no-build base case for each of the three regions. Specifically, the proposed methods will identify:

- The change in or incremental user benefits attributable to each scenario;
- The change in or incremental societal benefits attributable to each scenario;
- The change in or incremental implementation costs for each scenario; and
- The change in or incremental ongoing operation and maintenance costs for each scenario.

The changes in benefits will be assessed by selected modes, trip purposes and time periods, aggregated to daily totals and then expanded to annual values. Benefits to be considered include the net changes in travel time, user and vehicle operating costs (expressed as the net change in consumer surplus), and potential safety benefits/disbenefits from the change in the number of accidents. Changes in costs will be derived from a separate cost estimation task, and appropriately expressed in annual dollars relative to the baseline.

Considerations Beyond the Scope of this Study

For various reasons, including the conceptual nature of the projects being evaluated and the implementation of multiple projects simultaneously across the region rather than individual projects or corridors, the scope of the economic feasibility analysis is necessarily limited. Below are several topics or issues that are not explicitly included in the benefit-cost analysis methodology for monetary quantification, but may be discussed qualitatively.

- Induced demand for personal and freight/commercial truck travel — the analysis captures some of the induced demand effects (e.g., increased vehicle miles of travel), but not all. The scope for the travel demand modeling effort holds the trip tables — the overall level of trip-making — fixed. In other words, the improvements themselves are not assumed to generate new travel demand beyond what would otherwise exist. While the modeling does enable trips to be distributed among different paths, and to utilize different modes, it does not enable the creation of new trips altogether, or the shifting of trips from one time period to another. Similarly, the scope for the travel demand modeling effort does not enable the creation of new commercial truck trips due to facility improvements, though increased average trip distances may serve as a proxy for some of this effect. More discussion of induced demand is provided on page 19.

- Travel time reliability improvements — Travelers place a value on travel time reliability. However, much of the research that estimates the values that travelers place on time savings does not distinguish pure time savings effects from reliability improvements that may accompany those time savings. Other research has estimated the value of reducing the variance of travel time. Application of these methods would require estimating the change in the distribution or standard deviation of travel times by zonal pairs. However, the regional models are only equipped to provide average zone-to-zone trip times, and not any measures of variance. More discussion of travel time reliability is provided on page 20.

- Construction delay disbenefits and benefits — The effects of construction on traffic circulation will not be evaluated since the study's analysis year of 2025 assumes completion of all projects, and construction period travel conditions are not being modeled. Furthermore, since the scenarios being evaluated are largely conceptual, details on construction phasing for the projects are unknown. However, some of the construction delay disbenefits may be offset by the multiplied increased economic activity arising from the construction expenditures. The level of net benefits from construction expenditures will depend on what portion is funded from federal sources that would otherwise not be received, and on whether or not construction expenditures have greater multiplied impacts than other alternative uses for these resources.

- Analysis of economic development benefits and disbenefits— Enhancements that improve the operation of transportation facilities can improve the movement of people and goods. This increased mobility may act as a catalyst to increasing business opportunities in the region. Although the potential economic benefits of improvements in the operation of facilities will be discussed qualitatively, quantitative estimates will not be developed. Alternatively, there could be a number of economic disbenefits from a huge infrastructure investment. For example, the economic implications of right-of-way impacts to local businesses could be very considerable. In addition, the taxes required for a massive investment in public infrastructure could reduce resources available for other needs, such as schools, prisons, healthcare, small businesses, etc.

- Consideration of the possible need for additional parking supply and its associated cost — One may argue that a scenario that increases vehicle trips may lead to the need for additional parking, and that the cost of this parking should somehow be captured in the benefit-cost analysis. With the exception of park-and-ride lots, this analysis assumes that parking is primarily provided by the private sector, and would thus be subject to market parking rates that match supply with demand. Additional parking supply would likely be the result of private sector decisions in response to increased demand, with the projected parking revenue streams financing this cost. Since the assessment of user benefits includes the parking cost assumptions of the regional model, additional trip generation comes with additional user parking costs (disbenefits), which should (at least partly) account for this parking supply effect. In addition, preliminary modeling suggests that there is very little change in the overall number of vehicle trips generated by a scenario (less than half of one percent difference), suggesting that any parking supply and demand effects relative to the no-build will be marginal, further supporting the approach cited herein.

Benefit Assessment Methodology

Evaluation Period

A typical project evaluation period would include the construction period during which capital expenditures are undertaken, plus 20 to 30 years of operations beyond project completion within which to accrue benefits. Conceptually, this is:

Evaluation Period (Years) = Construction Duration + Operating Period

In an ideal setting, these time periods and the estimation of benefits and costs within them would not be constrained by a lack of data or procedures for estimating various inputs. Put another way, consideration of construction and operating components of the evaluation period presume that there exists a means to estimate each year's costs and benefits over the entire future period. For the purposes of this study, it has been assumed that all projects would be completed and fully operational by 2025, the future horizon year for which demand conditions are modeled. This means that annual benefits and costs would be needed from some reasonable start date such as 2010 through 2045 or 2050. Model outputs for at least two analysis years, both within or adjacent to the operating period dates, would be required to estimate annual benefits over this period.

However, the region-wide nature of this study necessarily imposes certain constraints that require simplifying assumptions. Specifically, construction schedules and phasing plans for the portfolios of projects comprising each scenario will not be developed with any detail, and the required inputs are not available to run the regional models for a second future analysis year beyond 2025, such as 2045 or 2050.

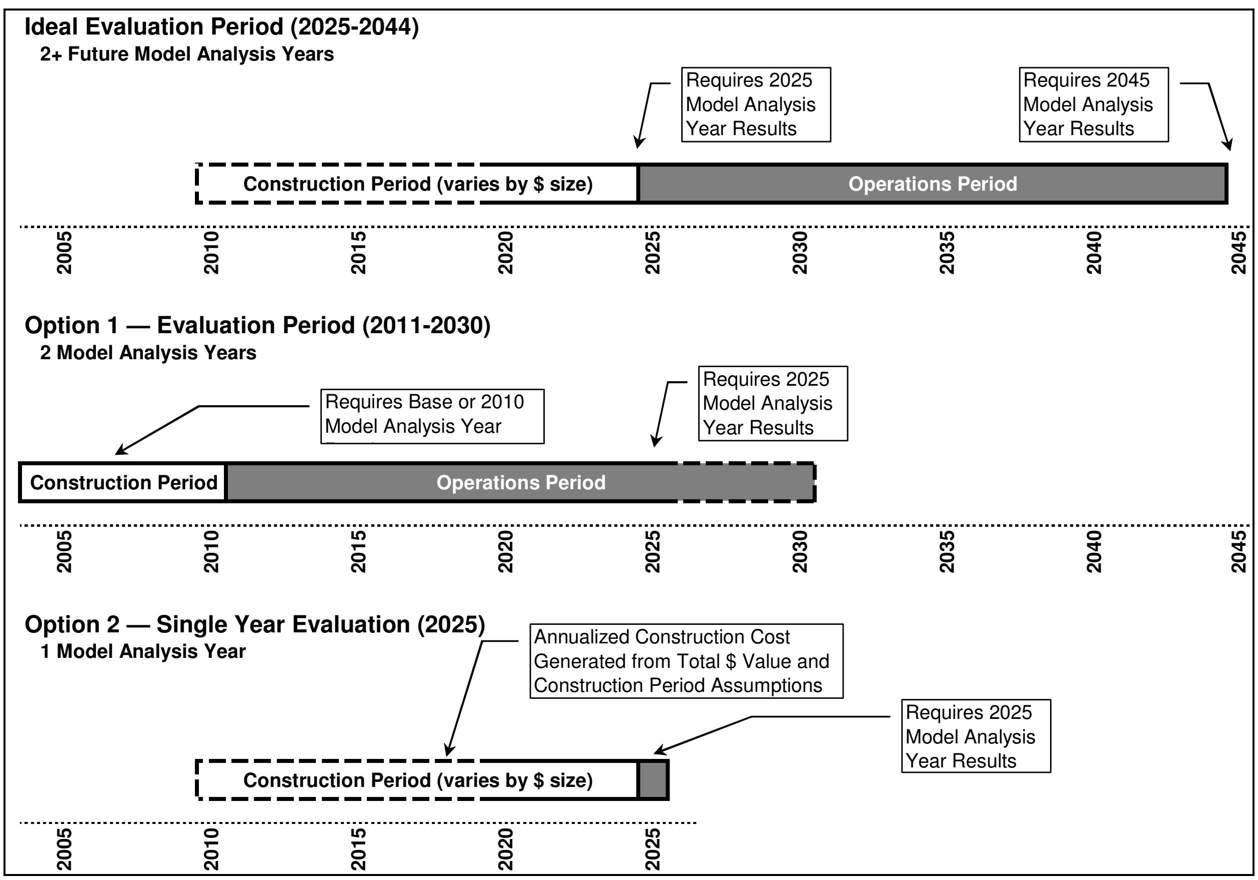
As such, some simplifying assumptions are required in the treatment of the evaluation period that are consistent with the guiding principle that all of the improvements are completed and generating congestion relief benefits in the year 2025. In the case of the construction period costs, general assumptions will be made that utilize a positive correlation between overall costs and construction duration across the scenarios. That is, it is assumed that the more costly a project is, the longer it will take to construct (more details follow below).

In the case of operating period benefits, the following lays out the issues regarding two available scenarios to the "ideal" evaluation period described above, and explains why Option 2 was selected.

Evaluation Period Issues Regarding Model Analysis Years

Figure 1 provides a graphical illustration of the "ideal" evaluation period and the two available surrogate options applicable to this study.

Figure 1 — Comparison of Evaluation Period Options



Option 1 — Two Model Analysis Years

The first option is to model a more near-term evaluation period that better fits two or more analysis years which can be modeled. In addition to 2025, inputs for a base year

(~2000) are available for each of the three regional models. Using outputs from the each model's base year, it is possible to interpolate benefits over the 15 year period from 2011 to 2025. Extrapolation of benefits over another five years to 2030 (or level extension of year 2025 benefits to 2030) would then yield the desired minimum 20 year operations period. This option, for purposes of the benefit-cost analysis only, would assume that all construction is highly compressed such that it is completed in 2010, so that 2011 would serve as the first year of full operations.

The advantages of the Option 1 approach are:

- Provides the typical and appropriate evaluation period focus, thus capturing some of how benefits may grow over time as travel demand grows; and
- Does not require extensive assumptions or modifications to the project costs, beyond a compressed construction duration (2005-2010) and the assessment of 2030 residual values for investments with an extended (50 year) useful life.

The disadvantages of the Option 1 approach, in the context of this study, are:

- The evaluation period is suboptimal in its assumption of an overly compressed construction period, which tends to raise the discounted present value of the cost, all else being equal;
- The evaluation period is also suboptimal by not aligning the operations period and its underlying conditions with a realistic future window for evaluating projects that would be in place by 2025, and by under-discounting future benefits;
- The rate of growth in benefits over the surrogate operations period will not likely match those over the ideal operations period;
- Future capacity constraints that would impact modes differently, thus changing the relative benefits generated across scenarios with different mode emphases, will not likely occur under the more near-term surrogate operations period;
- Will yield different B/C ratios and net present values than would the "ideal" evaluation period; and
- Additional travel demand modeling and the subsequent application of the SUMMIT user benefits program for an additional analysis year would be required.

In sum, an ideal future year such as 2045 or 2050 cannot be modeled, and the study's system-wide, multi-modal analysis framework precludes the use of other post-model techniques for extrapolating benefits out that far even if the necessary assumptions about growth in travel and benefits were available. As a result, the evaluation period must be artificially shifted to match dates where model outputs are, or could be, available.

Option 2 — A Single Model Analysis Year

The second, and currently preferred option, is to use only the 2025 model outputs to generate annual benefits for this single "representative" future year's travel conditions. With only one model analysis year, benefits for that year can be estimated, but there is no reliable means to assess growth rates or project these benefits to other years.

Under this condition, the annual benefits for 2025 cannot be directly compared to the full capital and O&M costs of the scenario. Rather, it is necessary to convert the capital costs of the scenario — which represent investments with useful lives that span decades — into an annual equivalent which can then be directly compared with annual benefits.

This annual equivalent to the capital cost can be thought of as the annual lease payment or "capital recovery factor" which would purchase this investment. Note that the terms of the "lease" correspond to a number of financial assumptions, including the useful life of the investment, which should be equal to or greater than the operations period that would otherwise have been used.

In cases where benefits are only available for one representative year (i.e., if modeling were to be performed for one year only), the formula and process for establishing the annual equivalent capital cost are provided below.

Equation 1 — Annual Equivalent Capital Cost

$$A = C \times \frac{r}{\left[1-(1+r)^{-n}\right]} \times (1+r)^{(t_1 - t_m)}$$

where:

C = the capital cost (in current dollars);

r = the real discount rate;

n = the project useful life = the operations period if investments have no residual value

> the operations period if investments have residual value

t_1 = the first year of operations;

t_m = the construction midpoint year; and

A = the annualized capital cost over n years

The advantages of the Option 2 approach, in the context of this study, are:

- Aligns well with the focus on a single 2025 analysis year, including the other performance measures based solely on 2025 conditions;
- Allows for more reasonable (less compressed) construction duration assumptions without requiring annual phasing assumptions;
- Requires less modeling effort than Option 1 (the additional modeling may not improve results commensurate with the effort, and may degrade them); and
- Avoids the potential distortions in measuring how benefits change over time that would likely exist under a suboptimal (advanced) evaluation period.

The disadvantages of this approach, in the context of this study, are:

- Does not capture how different investments may have different benefit growth rates over time;
- May not perform well if the single analysis year fails to be "representative"; and
- Will yield different levels of present value discounted costs and benefit than would the "ideal" evaluation period, though the relative rank order or comparison of different scenarios would likely be similar if not identical.

In sum, Option 2, like Option 1, may be viewed as suboptimal to the “ideal” evaluation period for estimating benefits; however, unlike Option 1, it does not impose unrealistic assumptions on the timing and duration of project costs.

A single-year measure of benefits is most successful when the project conditions are uniform across the scenarios being compared. Ideally, the model analysis year is selected such that the annual benefit, if experienced in every year of the project, would total to the same present value as the “true” trajectory of the entire trend of (variable) yearly benefits. In scenarios emphasizing highways or other modes which involve facilities that can become congested, exponentially rising "prices" or impedances cause benefits to grow at a different rate than demand, making the choice of a representative single year challenging. However, a similar distortion of benefits would likely occur under Option 1, as highway-oriented scenarios crafted to “fit” 2025 conditions would likely have excess capacity in earlier years, or a different overall benefit trajectory than would the ideal evaluation period.

Construction Period

Given that the focused and mixed scenarios of this study represent multi-billion dollar portfolios of projects region-wide, and are largely conceptual in nature, it is not feasible to estimate a detailed construction period schedule for the improvements associated with each scenario. In fact, as mentioned previously, the cost estimation effort is not specifically addressing construction schedule estimation, construction phasing, and/or other implementation constraints.

This requires that certain assumptions be made regarding project timing and construction duration to properly account for what would likely be a wide range of construction costs and schedules among the various scenarios.

For a given scenario, extending the construction duration with the year of opening held constant increases the present value of the construction costs (construction costs are brought closer to the present where they are less discounted). Thus, it would lower the potential net present value (NPV), because there would be no change to the 2025 benefit stream from which costs are subtracted. Conversely, holding the construction start year constant and extending the duration forward to move the year of opening further into the future will lower the present value of construction costs and potentially raise the NPV, depending on the rate of growth of benefits over time and the level by which construction is extended. Finally, compressing construction to move the opening year up to 2011 to fit an analysis period that corresponds with the modeling under Option 1 — Two Model Analysis Years, has the effect of both increasing the present value of the costs and increasing the present value of the benefits, all else equal. This is due to discounting over a shorter period, although the magnitude of gross benefits in each year will likely be lower in earlier years.

For the purpose of this study, given the absence of specific construction schedules, the magnitude of the total capital cost for each scenario serves as a reasonable proxy for construction duration. This relationship assumes that there are limited resources within each of the three regions for construction, and that pushing much beyond these limits would cause unit costs for construction labor and material inputs to increase sharply in order to attract new resources from other areas and/or industries. Put another way, the larger the total cost of a scenario, the longer it should take to construct, and thus theoretically, the longer the wait for benefits. No assessment of the true annual construction capacity will be made for each region, nor will the assumptions made necessarily be reasonable approximations of these capacities; rather, tying construction duration to the level of capital investment attempts to capture some of the notion that there are construction capacity constraints, or that the supply curve for construction activities is upward sloping.

A further assumption is made that those scenarios with relatively lower total capital costs/ construction durations would be started later, so that all of the scenarios would be completed at the same time (currently at the end of calendar year 2024). Finally, all capital investment costs including construction are to be expressed as ranges. With a few exceptions, the applied range is –5% to +25%.

Table 1 presents an example of the proposed assumptions for varying the duration of construction as a function the scenario's total capital cost (in today's dollars) as well as the midpoint year of construction and the construction start year that would yield an end of year 2024 completion.

It should be noted that some scenarios will have capital components with significantly different useful lives. For a scenario with a mix of infrastructure investments and transit vehicles such as buses, the infrastructure may have a useful life of 50 years and the vehicles only 10-12 years. In such cases, the scenarios overall capital costs will be divided into components with similar useful lives, and a separate annualized cost for each component will be calculated using Equation 1 and the capital investment timing assumptions from Table 1.

Table 1 — Construction Component Duration and Evaluation Period Dates by Capital Cost Value

Capital Program Size of Alternative (Today's $)			*Assumed Construction Duration*	*Evaluation Period Dates for 12/31/2024 Completion*		
				Construction Start Year	*Construction Midpoint Year*	*Total Implied Evaluation Period*
less than		$0.10 B	1 Year	2024	2024	21 Years
$0.11 B	to	$0.50 B	2 Years	2023	2024	22 Years
$0.51 B	to	$1.00 B	3 Years	2022	2023	23 Years
$1.01 B	to	$5.00 B	4 Years	2021	2023	24 Years
$5.01 B	to	$10.00 B	5 Years	2020	2022	25 Years
$10.01 B	to	$20.00 B	6 Years	2019	2022	26 Years
$20.01 B	to	$30.00 B	7 Years	2018	2021	27 Years
$30.01 B	to	$40.00 B	8 Years	2017	2021	28 Years
$40.01 B	to	$50.00 B	9 Years	2016	2020	29 Years
$50.01 B	to	$60.00 B	10 Years	2015	2020	30 Years
$60.01 B	to	$70.00 B	11 Years	2014	2019	31 Years
$70.01 B	to	$80.00 B	12 Years	2013	2019	32 Years
$80.01 B	to	$90.00 B	13 Years	2012	2018	33 Years
$90.01 B	to	$100.00 B	14 Years	2011	2018	34 Years
$100.01 B	or	more	15 Years	2010	2017	35 Years

If the analysis were to instead utilize the Option 1 methodology (two analysis years), the concepts would be similar, but with the overall range of construction duration significantly compressed, since all projects would be assumed completed by the end of 2010.

Operations Period

Even though the proposed approach examines annual benefits from a single representative year, a 20-year operations period is assumed for purposes of establishing the relevant total evaluation period, which is part of the calculation of the annualized cost for the capital investment. The operations period is implicitly assumed to be 2025-2044; this imposes a re-investment assumption for capital with a useful life of less than 20 years. It is not necessary to consider the remaining useful life of longer term capital investments after 20 years since capital costs are converted to the annualized values for comparison with year 2025 benefits.

Daily to Annual Expansion Factor

For the estimation of benefits, the highest time aggregation of data coming out of the regional models is at a daily level. In order to convert daily benefits to annual benefits, a daily to annual expansion factor of 300 is assumed. Assuming approximately 260 weekdays per year, this factor effectively weights weekend days at about 40% of the impact of a typical weekday.

Cost Estimates

The term “cost” within the framework of a benefit-cost analysis is understood to refer to the additional resource costs or expenditures required to implement, perpetuate and maintain the investments associated with a scenario, relative to the 2025 Baseline scenario/condition. Other costs attributable to a scenario that may be borne by users and/or society are handled in the estimation of benefits as negative benefits or disbenefits of the scenario.

A separate study effort details the cost estimation effort for the focused and mixed study scenarios. This effort provides the following inputs required for the benefit-cost analysis:

- The total implementation cost in current (year-end 2003) dollars for each scenario, expressed as a +/– range about an expected value, and including construction, capital equipment, roadway environmental impact mitigation, and right-of-way costs, but excluding any costs that would also be expended under the 2025 Baseline scenario; and
- The incremental annual operations and maintenance costs associated with each scenario, relative to the 2025 Baseline scenario, in current (2003) dollars.

In both cases, the focus is on those costs that would need to be expended above and beyond what would be spent anyway without the scenario. One nuance that sometimes arises is that an improved or new facility will actually lower O&M expenditures relative to the 2025 Baseline case if the existing facilities are sufficiently aged that they require a relatively high level of maintenance, more frequent rehabilitation, etc. However, this type of detail may not be available at a system level.

Note that the capital costs for scenarios with value pricing are assumed to include the capital costs for toll collection equipment. Similarly, O&M costs under a scenario with roadway value pricing are assumed to include the operations and maintenance costs for electronic toll collection and customer service operations, additional enforcement costs, and maintenance of the toll collection equipment.

The capital investments contemplated under the various scenarios are assumed to have an average useful life of 50 years for fixed facilities/infrastructure, and a useful life of 10-12 years for buses and 30 years for rail vehicles. Even though benefits are to be evaluated on an annual basis, a 20 year operations period is implied, and the annualized cost for investment with a useful life of less than 20 years includes an allowance for capital re-investment. Similarly, a residual value can be factored in by assuming a project useful life (*n*) from Equation 1 that exceeds the assumed 20 year operating period component of the evaluation period that would otherwise be applied for longer-lived capital.

Some O&M costs are routine, annual expenditures, and others are less periodic and more rehabilitation in nature. One example of these is pavement overlays, typically conducted every 10 to 20 years for highways. An annual factor for these periodic costs will be assumed and incorporated into the development of the annual O&M costs provided to the benefit-cost analysis.

User Benefits Estimation

User benefits will be estimated from the travel demand forecasting model runs for the various "focused" and "mixed" investment/value pricing scenarios, relative to the 2025 Baseline case. Benefits will be estimated for 2025.[1] User benefits or disbenefits are assumed to arise due to changes in:

- Person-trip travel time (including wait time for transit);
- Vehicle operating costs (e.g., fuel); and
- Other out-of-pocket costs (transit fares, tolls, parking charges, etc.)

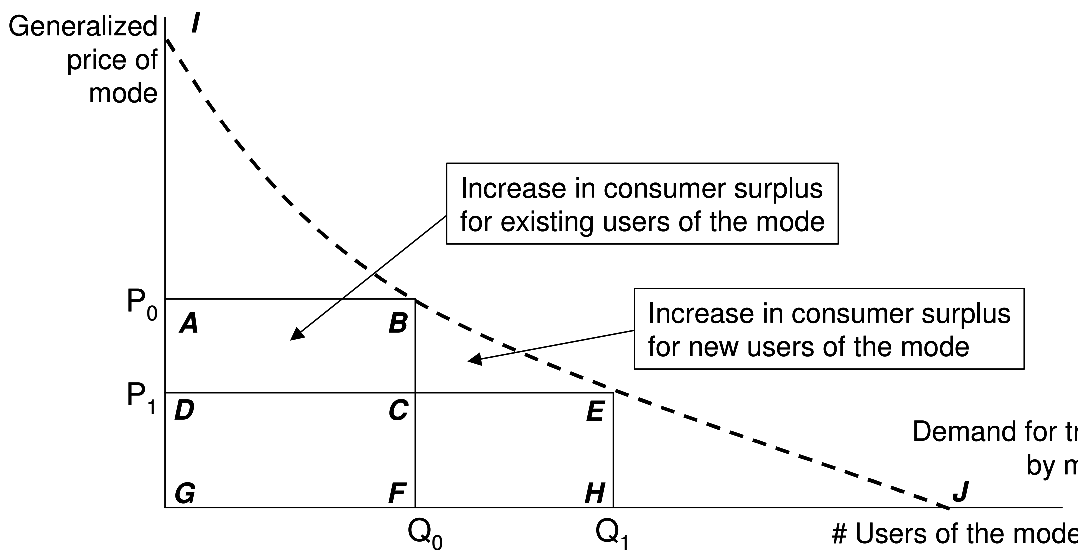
All of these factors contribute to the total cost or "generalized price" for travel faced by individual users. When a scenario's improvements cause changes in travel behavior that result in a change in the destination and thus, distance traveled, and/or a change in the mode distribution, consideration of these three factors individually by mode may lead to erroneous results, as the total change in consumer surplus —defined as the difference between the total willingness to pay and the total cost incurred by a group of users — will not likely be correctly accounted.

For example, an improvement that results in travel time savings for the auto mode will likely cause a mode shift to auto use, all else equal. If the change in travel time is assessed separately from all travel costs for either the baseline level of users or the scenario level of users, the benefits accruing to the new users of the mode will not be properly accounted. Instead, one needs to consider the total generalized cost for each mode in order to properly account for the consumer surplus benefits accruing to both the remaining and new/departing users of each mode.

[1] Note: if model runs are also available for the base year with the build network in place, these results will be used to interpolate and/or extrapolate benefits over an operations period within the evaluation period.

Figure 2 illustrates the accounting of user benefits equal to the change in consumer surplus due to a change in the generalized price of a mode of travel, such as auto travel time savings from a capacity improvement or person trip time savings from a transit improvement.

Figure 2 — User Benefit Estimation via a Change in Consumer Surplus



Using the demand curve illustrated in Figure 2 as an example, the baseline cost or generalized price of travel is P_0 under which there are Q_0 users, with a total cost or value of ($P_0 \times Q_0$) or the area of rectangle *ABFG*. The total consumer surplus for the baseline users is represented by the triangle area *IBA*. This is the collective additional cost that these users would have been willing to incur above what they have to incur. With the improvement under the scenario, the generalized price of travel declines to P_1 and the users of the mode increase to Q_1, with a total cost of ($P_1 \times Q_1$) or the area of rectangle *DEHG*, and consumer surplus represented by the triangle area *IED*. User benefits for the improvements associated with the scenario are represented by the net change in consumer surplus. For existing users numbering Q_0, the <u>increase</u> in consumer surplus from user cost savings is represented by the area of rectangle *ABCD*. For the new users of the mode who number ($Q_1 - Q_0$), the <u>increase</u> in consumer surplus is represented by the triangle area *BEC*, and the total <u>increase</u> in user benefits is the combined area of *ABED*. Combined with the initial consumer surplus denoted by IBA, the overall total consumer surplus at level Q_1 is bounded by the area IED.

This example can also be applied to trip distribution effects, where changes in destinations result in changes to vehicle miles traveled (VMT). In this case, the price axis becomes a price per VMT and the quantity of travel becomes total VMT rather than the number of users or trips.

For this study, user benefits will be effectively summed across all modes, trip purposes and time periods, as described later herein.

Assessing User Benefits from the Travel Demand Models

The procedures to be applied for estimating the total change in user benefits, as measured by the total change in consumer surplus, and summed across all travelers, trip purposes and modes, are based on those developed for the Federal Transit Administration (FTA) and applied within the travel forecasting model using the FTA SUMMIT software.

Summary of What SUMMIT Does

The SUMMIT user benefit procedures combine the changes in generalized travel prices and consumer surplus by mode, to arrive at the composite change in the price of all modes as a result of a scenario's transportation investments. This composite price of travel is derived from the "log sum" denominator of the logit equation within the mode choice component of the travel demand model and reflects the importance or share of travel by each mode. In covering all travelers, travel options, and travel attributes that are explicitly integrated within the mode choice model, the composite price of travel:

- Decreases with improvements to one or more travel option;
- Decreases with the addition of a new option; and
- Increases with the loss of an option.

SUMMIT is also amenable to all market segmentation that exists within the mode choice model, including segmentation by trip purpose/type, income level, etc.

Decreases in the composite cost of travel generate user benefits. In the case where total trip making is assumed to remain constant, which is a guiding assumption of this study, the change in consumer surplus is simply the change in the composite price of all modes multiplied by the number of person-trips or travelers.

The generalized price or cost of travel by mode, as well as the composite price of travel reflecting all modes, is measured in the units of time, and specifically, in-vehicle travel time. Travel time savings benefits are already expressed by the model in this price unit. Other costs or prices, such as tolls, parking, vehicle operating cost per mile, transit fares, and transit wait time are converted to time units using assumptions and factors within the mode choice logit equations of the travel demand model. Note that these assumptions are different for each region's travel demand model. For the final report, each region will document its overall model assumptions. The primary set of factors is the set of assumptions for the value of time by mode, trip purpose and/or time of day, though there are also assumptions for the various out-of-pocket costs as well as a factor that assess a premium for transit wait time over in-vehicle travel time.

Typical SUMMIT outputs would include *daily* user benefits in person hours by:

- Trip purpose or type (home-based work, home-based other, non-home-based);
- Mode of travel (transit and auto, where auto represents SOVs and HOVs); and
- Income classes for cases where trip purposes are segmented by income class within the mode choice model (e.g., home-based work trips are segmented into income quartiles within the PSRC mode choice model)

Although SUMMIT provides disaggregated benefits by all possible market segments, it does not provide a means to disaggregate user benefits by type of benefit, such as between travel time savings and vehicle operating cost savings. However, in most cases, time savings are the primary factor driving user benefits.

Model data regarding average vehicle occupancy, as well as independent assumptions for one or more values of time by market segment will then be used to value user benefits in monetary terms. A separate section discusses the value of time estimation and application.

Table 2 provides an example of the SUMMIT outputs, aggregated for daily travel by all trips as input to the benefit-cost analysis spreadsheet model.

Table 2 — Sample of Aggregated SUMMIT Outputs as Input to the Benefit-Cost Analysis

Model Outputs — User Benefits from SUMMIT & Daily Person-Trip Statistics			Daily Number of Person-Trips[1]	Total User Benefits (Hours)	User Benefits Distributed by Available Income Segments			
					Income Segment 1: 1st Quartile	Income Segment 2: 2nd Quartile	Income Segment 3: 3rd Quartile	Income Segment 4: 4th Quartile
Auto	Trip Purpose 1:	HBW	2,837,968	135,931	12,494	26,522	40,274	56,641
	Trip Purpose 2:	HBO	6,852,365	411,848	55,765	86,958	124,525	144,600
	Trip Purpose 3:	NHB	4,672,375	121,901	-	-	-	-
	Trip Purpose 4:		-	-	-	-	-	-
	Trip Purpose 5:		-	-	-	-	-	-
Transit	Trip Purpose 1:	HBW	457,603	2,634	831	527	571	705
	Trip Purpose 2:	HBO	308,751	787	421	200	112	54
	Trip Purpose 3:	NHB	85,051	365	-	-	-	-
	Trip Purpose 4:		-	-	-	-	-	-
	Trip Purpose 5:		-	-	-	-	-	-
Total	Trip Purpose 1:	HBW	3,295,571	138,565	13,325	27,049	40,845	57,346
	Trip Purpose 2:	HBO	7,161,116	412,635	56,186	87,158	124,637	144,654
	Trip Purpose 3:	NHB	4,757,426	122,266	-	-	-	-
	Trip Purpose 4:		-	-	-	-	-	-
	Trip Purpose 5:		-	-	-	-	-	-

Additional SUMMIT Software Details

SUMMIT is an executable computer program that accesses databanks from the regional travel demand models, through which the user interacts by altering instructions in a text-based control file. The SUMMIT program reads one baseline scenario file and one build scenario file for each trip purpose, and compares the data in each file to compute the total difference in the generalized price or cost of travel between the baseline and build scenarios, across market segments and transit accessibility markets, for each trip purpose.

The application of SUMMIT requires the following inputs:

- Standard user benefit format files from mode choice model;
- Matrix files (trips, impedances) from EMME/2 travel demand model software;
- “Flat” files with transportation analysis zone attributes;
- Control file with user inputs/instructions; and
- Zone-to-district equivalency table

SUMMIT provides the following outputs:

- Report file;
- User benefits files (tables of benefits by mode, trip purpose and other market segments);
- District-to-district user benefits tables;
- User-benefit zonal row-sum and column sum tables;
- Various files for further analysis;
- Trip-length frequency distributions (spreadsheet);
- Selected row-sums and column-sums for GIS mapping, if used;
- Selected row values and column values for GIS mapping, if used; and
- Zone-to-zone stratified trip tables in specified software format.

Commercial / Freight Travel Benefits

Commercial trips are estimated by the Puget Sound Regional Council (PSRC) and Southwest Washington Regional Transportation Council (RTC) regional travel demand models, but because they do not represent a travel choice in the mode choice model, the changes in hours and miles of travel for this market segment are not captured in the SUMMIT user benefits. Moreover, the models hold the overall number of commercial trips fixed; therefore, any changes in commercial travel attributed to a scenario are represented solely by changes in VMT. Nonetheless, commercial trips will benefit from improvements that relieve congestion, and these can be captured from model outputs for vehicle hours of travel and vehicle miles of travel for commercial trips.

In order to approximate the change in consumer surplus of the scenario relative to the baseline using the conceptual method put forth in Figure 2, it is necessary to estimate a total user cost per unit of travel for commercial trips.[2] Specifically, the vehicle hours of truck travel for the 2025 baseline and an evaluation scenario are multiplied by the appropriate value of time assumption for commercial trips and then divided by the respective commercial trip VMT to yield the dollar value per mile for each case. These values can then be added to the truck vehicle operating cost per mile — assumed to be a constant $0.65 per mile for the baseline and evaluation scenarios — to achieve user costs per mile for both scenarios. The difference between these two values is the user benefits (or disbenefits) accruing to commercial trips.

Essentially the same approach is used for the Spokane region, with the exception that commercial trips, vehicle hours of travel, and VMT must be grossly estimated from their total auto network counterparts, using an assumed value for the commercial trip share of total network trips.

If time savings and operating cost differentials were estimated separately, the change in consumer surplus would not be appropriately calculated. For example, it would be possible for a scenario with highway improvements to generate additional VMT appearing to result in an operating cost disbenefit that could more than offset the dollar value of overall time savings. However, this additional commercial VMT would only be undertaken if there were some benefit accruing to freight operators; this is the change in

[2] The measure of travel volume “users of the mode” represented by the horizontal axis in Figure 2 is substituted for commercial VMT.

consumer surplus represented by the change in supply and demand conditions that can be measured when considering the change in travel and total user costs together.

Another potential freight impact could be freight inventory costs associated with delay. However, a full detailed evaluation of freight inventory impacts goes beyond the scope of this study.

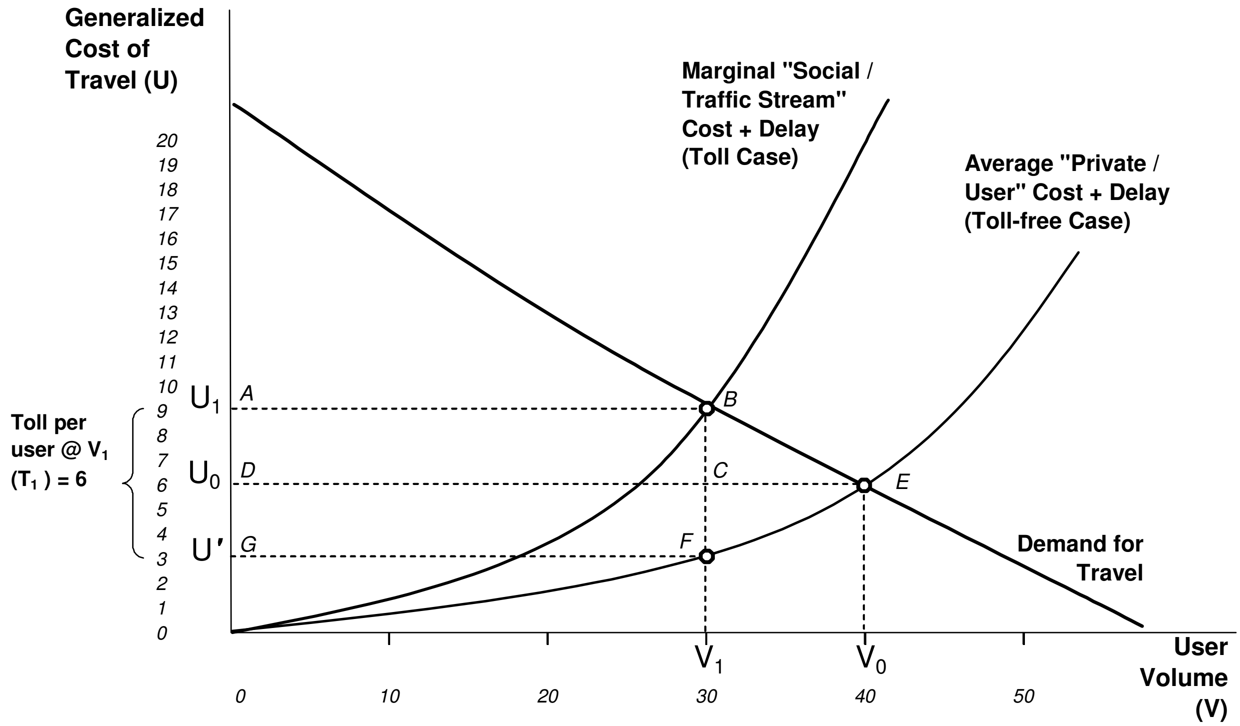
Roadway Value Pricing Issues

Scenarios with roadway value pricing are to be modeled using a modified volume delay function (VDF). This modification is designed to impose the true marginal social cost of travel rather than the typical marginal private cost perceived by individual travelers. When users only consider their own travel time costs, roadways are underpriced, and over-consumption occurs, resulting in traffic congestion. Consideration of the full marginal social costs by system travelers leads to the economically efficient use of the network in which some trips are diverted to alternate routes, destinations, modes, etc., resulting in lower overall network travel times.

The incremental difference between the private and social marginal costs is the external delay cost that each user imposes on all other vehicles in the traffic stream. This incremental cost is equivalent to the “toll” that is necessary to most efficiently alter travel behavior, expressed as a time cost per mile. The model VDFs are typically exponential functions of the link volume or volume-to-capacity ratio such that the toll time cost is effectively zero when there is no traffic congestion, but then grows at an increasing rate as congestion begins to occur.

Figure 3 builds on the Figure 2 example by depicting the estimated change in user benefits before and after roadway value pricing.

Figure 3 — User Benefit Estimation for a Scenario with Roadway Value Pricing



U = total user cost including travel time (value of delay) & out-of-pocket costs
V = user volume (vehicles or passengers)
Case "0" denotes without pricing (baseline), Case "1" denotes with pricing (pricing alternative)

Toll at volume V_1 $(T_1) = (U_1 - U') = (9 - 3) = 6$

Gross User Benefits (GUB) $= -(U_1 - U_0) \times (V_0 + V_1)/2 = -(9 - 6) \times (30 + 40)/2 = -3 \times 35 = -105$

This is the change in consumer surplus (trapezoid ABED), which here is a reduction or negative value.
Note that the preceding (–) sign is required to convert user cost changes to the benefit perspective (costs are negative benefits).

Net User Benefits (NUB) = GUB + Toll Revenues $= -(U_1 - U_0) \times (V_0 + V_1)/2 + (V_1 \times T) = -105 + (30 \times 6) = 75$

This is positive, assuming that toll revenues are somehow returned to users or otherwise productively used on the payers' behalf.

An important accounting issue regarding toll revenues arises when considering the benefits and costs of scenarios that incorporate variable value pricing by modifying the VDF (in contrast to incorporating tolls within the mode choice model). Basically, the travel times that are reported by the travel demand models and utilized by SUMMIT in assessing user benefits between the scenarios with value pricing and the baseline are "incorrect." Specifically, the user benefits will include not only the true, or "pure" travel times, but also toll cost (expressed in time units under this procedure). In relation to Figure 3, SUMMIT will estimate the change in consumer surplus (gross user benefits) of going from user cost U_0 and volume V_0 to a higher cost U_1 inclusive of the toll and corresponding lower volume V_1, which is represented by the trapezoid area ABED, and is negative (a decrease in consumer surplus).

The unit travel cost with the toll is U_1 in the figure, but the effective travel cost net of the toll is U', which makes the value of the toll, $T_1 = U_1 - U'$. However, toll revenues are generally viewed as a cost offsetting transfer payment (a contribution to the project funding that reduces the tax share of the project cost), or as a benefit in which the revenues are put to some beneficial use on behalf of roadway users, and even society as a whole. For this study, the latter assumption is made that toll revenues are treated as a benefit (put to some other productive use benefiting roadway users) since it does not require a detailed financial analysis of how much of a scenario's cost can be funded by leveraging future toll revenues via the sale of bonds.

Therefore, it will be necessary to calculate toll revenue area bounded by rectangle ABFG and add it to the negative user benefits (–) ABED to yield net positive user benefits represented by the net area of (DCFG – BEC). Figure 3 also provides a numerical example where the gross user benefits provided by SUMMIT is –105 but the net user benefits after accounting for toll revenues is +75.

Toll Collection Costs

It should be acknowledged that there is a cost associated with operating a priced roadway network. This cost includes factors for toll road operations, enforcement, toll collection equipment maintenance, and customer service and billing functions. Since the methodology for this study assumes that toll revenues are accounted for as a benefit, it is necessary to add the costs of toll collection to the annual operations and maintenance costs associated with the value pricing scenario.

For purposes of evaluating scenarios with conventional electronic toll collection methods, it is assumed that the above mentioned costs of operating priced roadway facilities consume 10% of gross toll revenues, excluding roadway maintenance (which would be done anyway and is estimated and accounted for elsewhere.) For the case of comprehensive network value pricing, GPS tolling technology is assumed and a separate operating cost estimate will be prepared. In either case, the toll operations/collections cost amount will be applied to the cost side of the analysis as an annual cost.

Construction Delay Issues

Transportation construction projects can create significant congestion and delay, particularly if there are a number of construction projects underway at the same time. It's possible that the construction delays experienced during construction may take many years to recoup in travel time savings post-construction.

However, the benefit-cost analysis will not include an economic analysis of construction impacts. A quantitative analysis of construction impacts will not be possible since the projects analyzed are largely only conceptual at this point. In order to evaluate construction impacts, much more detailed information would be needed, including the phasing and duration of construction, and modeling of traffic impacts. This may be the subject of further study.

Induced Demand Issues

A transportation system improvement can increase traffic volumes through induced demand for trips. That is, the improvement will generate additional trips on the facility from either the shifting of trips to the improved segment from other segments, by shifting trips from one mode to another, or by encouraging new trips.

While the regional models account for part of induced demand effects (shifting of trips from one facility to another due to changes in capacity, reducing or increasing the length of trips, and shifting from one mode to another), the ability of the models to address induced demand for new trips is limited. In most cases, the models tend to redistribute trips to more distant destinations, thereby increasing the level of vehicle- or person-miles traveled as a proxy for actually increasing the level of trip-making.

This inability of four-step regional models to properly consider and forecast new induced travel may result in lower forecasts of traffic for a corridor, and thus, higher estimates of speed for a scenario's investments than would actually occur. Thus, the regional models may lead to the overestimation of a corridor's user travel time savings and an underestimation of the environmental costs.

However, this study is analyzing a system of improvements rather than just a corridor. Therefore, the diversion of trips from one facility to another should, for the most part, be captured. The analysis will not, however, capture entirely new trips for trips that are eliminated.

Developing estimates for the change in overall number of trips made is challenging to say the least. But even if estimates were developed, incorporating them into the benefit-cost analysis can be problematic. Specifically, it can be problematic to estimate the benefits to the induced travelers, other than they must exceed the costs of making the trip. Due to the problematic nature of estimating the benefits and costs of new trips caused by induced demand, and the guiding assumptions of the study which hold the level of trip-making constant, the treatment of new induced demand will be limited to a qualitative discussion.

For freight/commercial trips, it is conceivable that dramatic improvements in the travel times and reliability for freight movement could change the business models and logistics operations for many firms and/or attract additional trade and freight mobility commerce, thereby significantly increasing the level of freight movement and its associated benefits. However, the measurement of these effects along with the extensive modeling of industrial operations and trade has also not been included in study methods, although potential impacts will also be discussed qualitatively in the final report.

A similar situation occurs for trip elimination. For some scenarios, the models may shorten trip length but hold overall trip-making constant, rather then allowing for outright trip elimination. However, under a value pricing scenario, trip elimination would likely occur in addition to travelers altering their behavior by changing modes, destinations, time of travel and choice of route. Therefore, scenarios that include capacity enhancements may evaluate comparatively better than scenarios, such as value pricing, that do not.

Travel Time Reliability Issues

Travelers place a value on travel time reliability. Targeted survey research in the SR-91 corridor indicates that under certain conditions, travelers value improved reliability more than reductions in average travel time.

NCHRP 431 – Valuation of Travel Time Savings and Predictability in Congested Conditions for Highway User-Cost Estimation indicates that a good estimate for the value of travel time variance from which to assess improved reliability is $0.21 per minute of travel time standard deviation. However, the regional models employed in this study do not produce any information on zonal travel time standard deviations; rather only average zone-to-zone trip times by various market segments are provided.

Moreover, many of the guidelines for valuing travel time improvements as a function of the average wage rate are based on survey research studies that don't make distinctions between travel time improvements and reliability improvements. In such cases, survey respondents may knowingly or unknowingly assume that reductions in travel time are accompanied by reductions in travel time variability as well. As such, common assumptions for the value of travel time savings based on such studies may also embed reliability improvements. Put another way, if travel time savings and reliability factors could be adequately separated, one might find that the value of time for time savings is lower than the assumptions used in current practice.

Lacking the ability to assess the variance of the mean travel times estimated within this study, travel time reliability improvements will not be separately addressed as part of the benefit-cost analysis. However, in cases where improvements in reliability are expected, then the true benefits would likely be understated. Sensitivity analyses will be conducted to help understand if consideration of travel time reliability would have a major impact on the analysis results.

Societal Benefits Estimation

For purposes of this study, societal benefits are those that accrue either directly or indirectly to users and non-users alike, or accrue to users in a manner that is not perceived at the individual trip level. Societal benefits considered herein include safety benefits/disbenefits from the potential for accident levels to change, and benefits/disbenefits from changes in vehicle ownership costs as a result of lower levels of vehicle travel. One societal benefit that will not be included in the benefit-cost evaluation is emissions benefits or impacts. The estimation of emissions impacts will be included in a separate environmental performance measure. Therefore, the study will not monetize the emissions impacts, but will consider them as a performance measure.

Accident-Related Safety Benefits

Safety benefits are measured in terms of the changes in accident costs. Accident costs are a function of the number of accidents, and the type of severity of accidents.

For each scenario analyzed (each Focused and Mixed-Scenario), daily VMT by facility type is needed for the safety benefits analysis by the following facility classes:

- Freeways;
- State Highways/Expressways;
- County Roads/Rural Arterials; and
- City Streets/Urban Arterials.

Average Accident Rates

Accident rates are a function of speed, density of traffic, the geometric design of a facility in question, driver behavior, and other variables. Models have been developed to predict accident rates on transportation facilities in order to compare between scenarios. The structure of accident prediction models, however, can vary widely. A simple model can predict accident rates in terms of accidents per 100 million vehicle-miles traveled for different types of roads. For a more detailed, project level analysis, models have been developed to predict accidents based on factors such as average daily traffic, lane and shoulder widths, driveway density, roadside hazard rating, horizontal curve lengths and radii, and vertical curve lengths.

Congestion may also play a role in accidents, although some of the research and data regarding the impact of congestion on accident rates appears contradictory. For example, data developed as part of an I-90 project in Seattle showed more serious accidents (fatalities and disabling injuries) during congested periods, but an overall lower accident rate for the "more congested" than the "less congested" roadways. Data developed as part of an I-405 project in the Puget Sound area showed higher fatality rates for uncongested facilities (likely owing to higher speeds), but lower overall accident rates for uncongested roadways. A study completed in Michigan[3] indicated that crash rates are very high at low levels of congestion but rapidly decrease with increasing V/C ratios, before gradually increasing again at peak levels of congestion. This U-shaped model held true for overall weekday and weekend crashes, multi-vehicle crashes, rear-end crashes, and property-damage-only crashes. On the other hand, the accident rates for injury and fatality accidents increased with the V/C ratio at all values. Another study[4] showed essentially a straight line relationship between v/c ratios and crash rates. Perhaps a complicating issue is that for most studies, the data applies to only one or very few facilities, so the rates may reflect characteristics specific to a particular facility.

Because only a limited amount of project design data is available as part of the Congestion Relief Analysis study, and because data and research analyzed linking accident rates to levels of congestion appears to be inconclusive and often based on one specific roadway facility, the assessment of safety benefits will rely on a simplistic analysis of the potential levels of accidents using historical accident rates as a function of VMT for the four facility types previously indicated.

Specifically, for each focused and mixed-scenario, regional model output will indicate total VMT by link type, and each link type will be matched with the most appropriate facility type-specific accident rates shown in Table 3. Using WSDOT average statewide accident rates by accident severity and facility type, the number of accidents by severity for each scenario will be estimated.

Note that safety benefits are examined from a network or system-wide perspective by all facility classes as a function of VMT, and thus, are not confined just to those facilities being improved.

In general, scenarios that result in increased VMT should result in higher accident costs in the benefit-cost analysis, while scenarios that result in decreased VMT should result in lower accident costs. However, VMT shifting from one facility to another will also affect accident costs. As shown in Table 3 below, overall accident rates per 100 million VMT are lower on freeways than on expressways or arterials. Therefore, a shift in travel to

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[3] Source: Zhou, M. and Sisiopiku, V.P. (1997). `On the Relationship between Volume to Capacity Ratios and Accident Rates', Transportation Research Record 1581, Washington, D.C., pp. 47-52.
[4] Source: Shelby Tedesco, Vassili Alexiadis, William Loudon, Richard Margiotta, and David Skinner, Development of a Model to Assess the Safety Impacts of Implementing IVHS User Services, Proceedings, IVHS America, 1994.

freeways from another type of facility may reduce the number of accidents depending on the overall change in VMT.

Table 3 — Accident Rates by Facility Type and Severity

Facility Type / Classification	Accident Rates by Type per 100 Million VMT			
	Total (All Types)	Fatality Accidents	Injury Accidents (Non Fatal) [3]	Property Damage Only Accidents [3]
Interstate System [1]	114.3	0.6	38.1	75.6
State Highways [1]	204.3	1.6	67.8	134.8
Combined Interstate and State Highways [4]	160.4	1.1	53.3	106.0
County Roads [2]	218.0	2.4	72.2	143.4
City Streets [2]	418.0	0.7	139.7	277.6
Combined County & City Arterials [4]	341.0	1.4	113.7	226.0

[1] Source WSDOT, based on average of rates for 1999 through 2002.
[2] Source WSDOT, based on 2002 data only (no data available for 1999 through 2001)
[3] Based on USDOT Traffic Safety and Facts 2000. Percentage of Accidents Involving Injuries and Property Damage Only Applied to WSDOT Total Accidents Rate
[4] Reflects a VMT-weighted average of the preceeding two facility types.

Average Accident Costs

Estimates for the comprehensive economic costs of avoiding accidents are required to value the changes in the number of accidents in order to assess safety benefits for the benefit cost analysis. The comprehensive economic costs of accident avoidance are typically higher than the calculable costs of actual motor-vehicle crashes, the latter being based on wage and productivity losses, medical expenses, administrative expenses, motor vehicle damage, and employer costs. In other words, historical accident costs do not include the value of a person's natural desire to live longer or to protect the quality of one's life. In essence, people are willing to pay more for improved safety.

Table 4 provides these comprehensive economic costs for avoiding accidents by accident severity, which are the appropriate values to use for benefit-cost analysis.

The economic costs of accidents used in a benefit-cost analysis should be net of the average insurance reimbursement in special cases where insurance costs are included in the generalized price of travel used in the regional models and for the assessment of user benefits. However, the regional models employed for this study do not include insurance as a user-perceived marginal cost of travel; thus,

Table 4 presents the total accident costs by three types or levels of severity.

Table 4 — Average Auto Accident Costs by Severity (2002 Dollars)

Accident Severity	*Historical Calculable Cost*	*Comprehensive Economic Cost of Avoidance*
Death	**$ 1,090,000**	**$ 3,470,000**
Nonfatal Disabling Injury	**$ 39,900**	**$ 119,650**
Incapacitating Injury (A)	$ 52,100	$ 172,000

Nonincapacitating Evident Injury (B)	$ 17,200	$ 44,200
Possible Injury (C)	$ 9,800	$ 21,000
Property Damage Crash (including non-disabling injuries)	**$ 6,200**	**$ 8,200**

Source: National Safety Council (http://www.nsc.org/lrs/statinfo/estcost.htm#COST)

Accident-Related Delay Reduction Benefits

Accidents also create economic costs via the congestion delay they impose on the traffic stream, especially when traffic is relatively heavy. Vehicular accidents can block traffic and divert drivers' attention, and the impacts of an accident on traffic flow can continue long after the accident is cleared due to the build up of vehicle queues.

The delay caused by an accident depends on its duration (how long it takes to clear it), whether the accident blocks a lane, the number of other lanes available on the roadway, and the traffic volume. This study will include a system-wide estimate of the impact of accidents on delay by using the following assumptions:

- For the purpose of the accident delay analysis, all freeways will be assumed to carry three lanes in each direction. The analysis recognizes that in actuality some will have more lanes and others fewer, but three lanes will be the average assumed.
- Average accident duration is 45 minutes.
- Sixty percent of accidents occur on the shoulder and incur 670 hours of system delay; forty percent block one lane and incur 1,750 hours of system delay. Therefore, the average freeway accident incurs 1,100 hours of system delay. (These delay values are based on research in *Incident Management*, prepared for the Trucking Research Institute/ATA Foundation, Inc. by Cambridge Systematics, Inc., 1990.)
- Accident delay will only be measured on freeways during peak periods.
- The number of accidents for the delay analysis will be based on peak period VMT, calculated using the accident rates identified previously.

Vehicle Ownership Cost Savings Benefits

The user perceived, marginal costs of travel are captured in the estimation of user benefits. However, if a particular scenario results in a significant change in travel behavior (reflected in the level of VMT), it may change vehicle ownership patterns as well. For example, a transit rich scenario that results in reduced system-wide VMT may lead some households to decide that they can get by with one less car. Conversely, a scenario that results in considerable roadway expansion and increased system-wide VMT may lead some households to decide that they need an additional car. For purposes of this study, it is assumed that a small minority (10 percent) of the change in VMT results in an absolute change in vehicle ownership, while the majority (90 percent) of the change in VMT results in a change in vehicle use (more or fewer miles driven each year), resulting in changes in ownership costs.

Specifically, the following assumptions are used in this analysis:

- 90 percent of a difference in annual VMT of a scenario relative to baseline will result in a change of vehicle usage only, resulting in a change in the vehicle depreciation and finance cost components of ownership;
- 10 percent of a difference in annual VMT relative to baseline will result in a change in vehicle ownership (more or fewer cars needed), resulting in a change in the full cost of auto ownership;
- Full ownership cost is $0.30/mile (see Table 5);
- Depreciation/finance cost is $.18/mile (see Table 6); and
- An average annual vehicle mileage of 12,000 (per FHWA).

An example calculation is presented in Table 7.

Table 5 — Reduced Vehicle Ownership Costs for 10 Percent of Reduced/Increased System-wide Annual VMT

Category	Small Car	Midsize Car	Large Card	SUV	Van	Average
Insurance	$ 1,104	$ 965	$ 1,104	$ 1,435	$ 1,060	
License, registration, taxes	$ 191	$ 243	$ 304	$ 447	$ 427	
Depreciation at 15,000 miles per year	$ 3,130	$ 3,659	$ 4,453	$ 3,978	$ 3,782	
Depreciation Adjustment (per 1,000 miles over or under 15,000 miles annually)	$ 165	$ 175	$ 184	$ 140	$ 171	
Depreciation at 12,000/miles year	$ 2,636	$ 3,133	$ 3,902	$ 3,557	$ 3,269	
Finance charge	$ 657	$ 885	$ 1,167	$ 1,044	$ 971	
Total Ownership Costs	$ 4,588	$ 5,226	$ 6,477	$ 6,484	$ 5,728	
Total Ownership Costs Per Mile	$ 0.38	$ 0.44	$ 0.54	$ 0.54	$ 0.48	
Adjusted Total Ownership Cost Per Mile*	**$ 0.25**	**$ 0.27**	**$ 0.33**	**$ 0.35**	**$ 0.30**	**$ 0.30**

*Depreciation and finance charges halved, per recommendation from NCHRP report referenced below, page 5-10

Source: *User Benefit Analysis for Highways*, American Association of State Highway Transportation Officials, 2003, page 5-10, and *Your Driving Costs*, American Automobile Association, 1999, escalated to 2003 dollars by Parsons Brinckerhoff.

Table 6 — Reduced Vehicle Depreciation/Finance Costs for 90 Percent of Reduced/Increased System-wide Annual VMT

Category	Small Car	Midsize Car	Large Card	SUV	Van	Average
Depreciation at 15,000 miles per year	$ 3,130	$ 3,659	$ 4,453	$ 3,978	$ 3,782	
Depreciation at 12,000/miles year	$ 2,636	$ 3,133	$ 3,902	$ 3,557	$ 3,269	
Finance charge	$ 657	$ 885	$ 1,167	$ 1,044	$ 971	
Total Vehicle Depreciation/Finance Cost	$ 3,294	$ 4,018	$ 5,069	$ 4,602	$ 4,240	
Total Vehicle Depreciation/Finance Cost Per Mile	$ 0.27	$ 0.33	$ 0.42	$ 0.38	$ 0.35	
Adjusted Vehicle Depreciation/Finance Cost Per Mile*	**$ 0.14**	**$ 0.17**	**$ 0.21**	**$ 0.19**	**$ 0.18**	**$ 0.18**

*Depreciation and finance charges halved, per recommendation from NCHRP report referenced below, page 5-10

Source: *User Benefit Analysis for Highways*, American Association of State Highway Transportation Officials, 2003, page 5-10 and *Your Driving Costs*, American Automobile Association, 1999, escalated to 2003 dollars by Parsons Brinckerhoff.

Table 7 — Example Calculation of Vehicle Ownership Cost Changes

	Scenario Resulting in Higher VMT	Scenario Resulting in Lower VMT
Sample Baseline Annual VMT	2,500,000,000	2,500,000,000
Sample Scenario/Alternative Annual VMT	2,625,000,000	2,375,000,000
Difference Between Baseline and Alternative	125,000,000	-125,000,000
10% of VMT Change Affects Ownership	12,500,000	(12,500,000)
Cost Increase/Reduction for Vehicle Ownership	$ 3,727,337	$ (3,727,337)
90% of VMT Change Only Effects Vehicle Use (Depreciation, Finance Charges)	112,500,000	(112,500,000)
Cost Increase/Reduction for Changes in Vehicle Use	$ 19,896,970	$ (19,896,970)
Total Annual Cost of Alternative Due to Change in Auto Ownership or Use	**$ 23,624,307**	**$ (23,624,307)**

Value of Time Assumptions

User benefits outputted by the SUMMIT procedures are expressed in person-hours of equivalent in-vehicle travel time. In order to value these benefits in dollars, assumptions for the value(s) of time are needed. The value of time (VOT) is typically related to the prevailing average wage rates for the region.

Employment and earnings data provided by the Washington State Employment Security Department were used to estimate the average wage rates in each of the three study regions. The data used is the most recent available covering the fiscal year from July 1, 2002 through June 30, 2003. Table 8 presents average wages estimated for each region.

Table 8 — Average Wage Rates by Region (Fiscal Year 2003)

Region	*Average Hourly Wage*
Puget Sound Region (Weighted average of King, Pierce, Snohomish & Kitsap Counties)	$22.50 / hour
Southwest Washington (Clark County)	$17.00 / hour
Spokane Region (Spokane County)	$15.10 / hour

Time spent in travel has an opportunity cost — the value of the next best or alternative use of this time, assuming the traveler could somehow devote this time to other activities. Congested traffic conditions increase travel time for system users; reductions in those travel times are considered to be user benefits. The amount a traveler is willing to pay for that reduction in travel time is related to their opportunity cost and is assumed to be directly proportional to their average hourly wage.

Values of Time for Personal Travel by Trip Purpose

The U.S. Department of Transportation provides guidance on wage rate factors by different travel purposes, modes and distances, as based on survey research.[5] By "in-vehicle" time for surface transportation modes, these recommendations range from 50% of the average wage rate for local personal travel to 100% of the local wage rate for intercity business travel.

For purposes of this study, a value of 50% of the average wage rate in each region will be used to convert non-work user benefits as measured in hours to dollars.[6] A value of 60% of the average wage rate will be used to value user benefits for work purpose trips.[7] This slightly higher percentage reflects that work purpose trips may have a slightly higher value of time, and that the majority of such trips happen during the morning and afternoon peak periods, when congestion relief improvements will be more likely to improve not only travel times, but also travel time reliability (which is not directly measured). Recognizing that the user benefit measures provided by SUMMIT encompasses changes in both time and monetary costs of travel, the average wage rate factor applied to work trips is lower than might otherwise be applied to pure travel time changes.

In cases where the regional model provides results segmented by income classes, the average wage rate-based value of time assumption will be used to calibrate available US Census data on income distribution to develop adjusted, income class-specific values of time.[8] In these cases, different values of time would effectively be applied not only by trip purpose, but also to travel by each of the available income groups for which user benefits can be segmented.

Income-specific values of time will be conservatively estimated not to vary substantially from the average due to the challenges in appropriately matching the regional income distributions to the travel demand model's income categories, and the fact that there is some evidence that the value of time for certain trips by lower income groups is not proportionately lower to those of higher income groups. Lower income groups may be more likely to work in occupations that have strict work day start and end times, and/or in which the penalties for being late to work are relatively high. Similarly, penalties imposed by daycare providers for being late to pick-up dependents affect all income groups the same. These examples suggest that, on the margin, the value of time for many trips may be more uniform than income distribution would suggest, and supports the notion of minimizing the variance in the set of time values applied in most cases.

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[5] "The Value of Travel Time: Departmental Guidance for Conducting Economic Evaluations," U.S. Department of Transportation, 1997, revised February 2003.
[6] Non-work trip purposes are categorized as home-based to other trips and non home-based trips.
[7] Work purpose trips include home-based to work trips, and include trips primarily made during peak time periods.
[8] The PSRC and Spokane regional models provide income segmentation for selected trip purposes/types.

Commercial Travel Value of Time Factor

The value of time for commercial vehicles should be valued at no less than 100% of the total compensation of the driver.[9] Total compensation implies the driver's wage plus the fringe benefits costs incurred by the business owner, as this is the opportunity cost for the business owner for delays in freight movement (assuming that the cargo itself is not perishable.)

For purposes of this study, this value of time is approximated by 120% of the average wage rate in each of the three regions.

Real Growth in Values of Time

Historically, wages and salaries have increased, on average, at a higher annual rate than general price inflation. Increases in the level of wage and salary incomes per job above and beyond general inflation are referred to as real increases. Between 1970 and 2000, average wage and salary incomes in King County grew at an inflation adjusted average annual real rate of 1.25%, while the State as a whole saw average real growth of 0.73% per year.[10] For purposes of this study, future real growth in wage and salary incomes, and thus, values of time was assumed to be 1% per annum. In 2025, the average wage rates shown in Table 8 and the values of time derived from these figures would be 24.5% higher — expressed in 2003 dollars before considering inflation — due to real growth between 2003 and 2025.

Regional Differences in Values of Time

The average wage rates in Table 8 yield values of time with a fair amount of regional variation. Possible causes or market differences include different pay rates for the same job, a different distribution of employment by various industry sectors, and/or the effects of differences in the cost of living. In any event, this results in different monetary benefit values per unit of benefit among the three study regions. It is fair to consider these regional differences in values of time because different economic conditions do contribute to different levels of willingness to pay for benefits generated. Moreover, the cost estimates feeding the benefit-cost analysis are also region-specific, resulting in different unit costs among the three regions for the same construction activity or product. In general, lower regional construction costs occur in lower average wage rate regions, and vice versa, thus properly controlling the benefit-cost analysis results for what might otherwise be perceived as an inequitable means of estimating benefits. For purposes of this study, it was deemed appropriate to use region-specific values of time rather than one statewide average value.

Real Discount Rate Assumption

Benefits and costs for this analysis have been valued in constant 2003 dollars to avoid having to project future inflation and escalate future values accordingly. Therefore, it is appropriate to use a real discount rate for present value discounting. A real discount rate measures the risk-free interest rate that the market places on the time cost of

[9] "User Benefit Analysis for Highways," American Association of State Highway Transportation Officials, 2003.
[10] Calculated from wage and salary data obtained from the Washington State Employment Security Department and price level data from the U.S. Bureau of Economic Analysis' Implicit Price Deflator.

resources, when valued in constant dollars such that any inflation premiums have been extracted. For a given evaluation period, U.S. government securities of similar maturity provide an appropriate estimate of the real discount rate, where the real rate is the difference in yield between a nominal Treasury bond and a "Treasury Inflation-Indexed" bond of the same maturity. Historically, this risk-free real interest rate has generally been within the range of 3.0 to 4.0 percent, and at present, it is near the low end of this range. The U.S. Office of Management and Budget (OMB) provides guidance on an appropriate real discount rate for projects that involve federal funding.[11] As of January 2003, the 30 year real discount rate recommendation was 3.2 percent. For purposes of this study, a real discount rate of 3.5 percent is assumed.

Economic Feasibility Criteria

As previously noted, the typical benefit-cost or economic feasibility evaluation measures (B/C ratio and NPV) will not be reported as single values. However, the discounted present values of annual benefits and costs will be presented as ranges to facilitate some comparison of benefits and costs. A scenario would be considered economically feasible — having positive economic value relative to the 2025 Baseline with respect to the quantifiable benefits and costs discussed herein — if the range of benefits exceeds the range of costs. A scenario may also be considered potentially economically feasible if for part of their respective ranges, benefits exceed costs. Scenarios not meeting these conditions may still generate significant benefits, but those benefits would either be insufficient to offset the costs, or the benefits would be projected to occur at points in time too distant in the future for the scenario to be deemed economic feasible". Since the scenarios considered for this study involve large portfolios of multiple individual "projects", in a situation where a scenario does not evaluate favorably, it may still be the case that many of the individual projects or combinations of projects would be economically feasible.

Summary of Data Inputs Required

Benefit Calculation Inputs

A list of benefit calculation inputs are described below. The final analysis needs to result in annual benefits and costs. To obtain annual benefits and costs, the analysis relies on daily benefits and costs, then applies a factor to estimate annual benefits and costs. However, SUMMIT will consider the time periods of the models and then aggregate to daily. Most of the other model inputs are the sum of the various periods to get to daily. Therefore, the analysis does not exclude consideration of the peak period impacts. However, because the analysis is not only considering peak periods, and since the costs are annualized, benefits are aggregated into daily benefits.

The following benefit calculation data inputs are required for each scenario and model analysis year:

- User benefits by market segment produced by the SUMMIT software;

[11] Office of Management and Budget OMB Circular No. A-94, Appendix C (Revised January 2003.)

- For scenarios involving roadway value pricing, model outputs needed to derive the portion of user benefits corresponding to the tolls paid (travel time matrices for a “toll assignment” and “zero toll assignment” as described previously);
- Daily commercial vehicle hours of travel (or an assumption for trucks as a percentage of network trips);
- Daily commercial vehicle miles of travel;
- Summary of mode choice model assumptions regarding vehicle operating costs and other out-of-pocket costs such as transit fares, parking charges, etc. with indication of which year’s dollars are used to express various costs;
- Model data regarding average vehicle occupancy on a daily basis, and if available, by model time periods and/or trip purposes; and
- Daily system-wide vehicle miles traveled, broken out by each facility type or link class in the model (e.g., freeways, expressways, rural arterials and urban arterials).

Cost Calculation Inputs

The following cost data inputs are required for each scenario:

- Total implementation cost in constant 2003 dollars, including construction, capital equipment (e.g., toll collection equipment for value pricing scenarios), roadway environmental impact mitigation, and right-of-way costs, and excluding any costs that would also be expended under the 2025 Baseline scenario;
- A distribution of the above by (1) infrastructure and all other investments assumed to have a 50 year useful life and by (2) other capital with shorter life spans and the assumed useful life for each category (e.g., transit bus vehicles, 10-12 years);
- Annual operations and maintenance costs associated with each scenario, relative to the 2025 Baseline scenario, in constant 2003 dollars, including costs for toll collection, customer service and enforcement under scenarios with roadway value pricing; and
- Transit farebox recovery ratio assumptions for scenarios with transit investments.

Spreadsheet-based Evaluation Tool

A spreadsheet-based tool will be developed and used to evaluate the economic feasibility of approximately 10 scenarios for each region. The tool will accept the inputs from the regional travel demand models summarized above, including the user benefits provided by SUMMIT as well as other model travel data (VMT, VHT, etc.) as required for estimating commercial vehicle benefits, accident-related benefits, and auto ownership savings benefits. It will also accept and process the capital and O&M cost estimates provided under a separate work effort.

The tool will be designed to be transparent in the way it aggregates and manipulates this input data to arrive at the discounted net present value ranges for the benefits and costs of each scenario, relative to the 2025 Baseline. The subset of total benefits comprising user benefits will also be provided on a per trip basis by trip type. Finally, the tool will also allow variation of key assumptions to facilitate certain types of sensitivity analyses that may be of interest. Table 9 provides an example of the summary results output from this tool for expected values (not ranges). Table 10 provides an example of the evaluation of annual benefits and costs, in this case for the low end of their ranges.

Finally, Table 11 provides an example of how the discounted present values of benefits and costs could be presented for each region's scenarios considered within this study.

Table 9 — Sample Evaluation Tool Summary Results Output

Congestion Relief Analysis Study
Benefit-Cost Analysis Results

Region: **Puget Sound**
Scenario: **High Hwy Low Transit**

Item Description	*Base Amounts (2003 Dollars)*	
	Undiscounted	*PV Discounted**
Total Capital Investment Cost	$80.02 B	$46.15 B
Annualized Capital Investment Cost	$4,289.9 M	$2,438.7 M
Annual O&M Cost in 2025	$510.0 M	$239.3 M
Total Annual Cost	$4,799.9 M	$2,678.0 M
Transportation System User Benefits (Disbenefits) in 2025[1]	$3,649.6 M	$1,712.2 M
Commercial Trip Benefits (Disbenefits) in 2025	$805.7 M	$378.0 M
Accident-Related Safety Benefits (Disbenefits) in 2025	($46.8 M)	($21.9 M)
Accident-Related Delay Benefits (Disbenefits) in 2025	($39.5 M)	($18.5 M)
Auto Ownership Benefits (Disbenefits) in 2025	($279.8 M)	($131.3 M)
Total Annual Benefits in 2025	$4,089.2 M	$1,918.5 M
2025 Average Daily Benefits per:		
Auto Person-Trip	$0.76	$0.35
Transit Person-Trip	$1.50	$0.70
Person-Trip (All Modes)	$0.80	$0.38
Commercial Trip	$1.67	$0.78

*Present value (PV) based on # of years from 2003 to year of expenditure/benefit using a 3.5% real discount rate.
[1] Includes changes in travel time and out-of-pocket user costs for both auto and transit modes as summarized from the outputs of the FTA SUMMIT program.
[2] Net present value (NPV) = discounted PV of 2025 benefits less discounted PV of annual costs in 2003 dollars.

Distribution of Benefits by Type

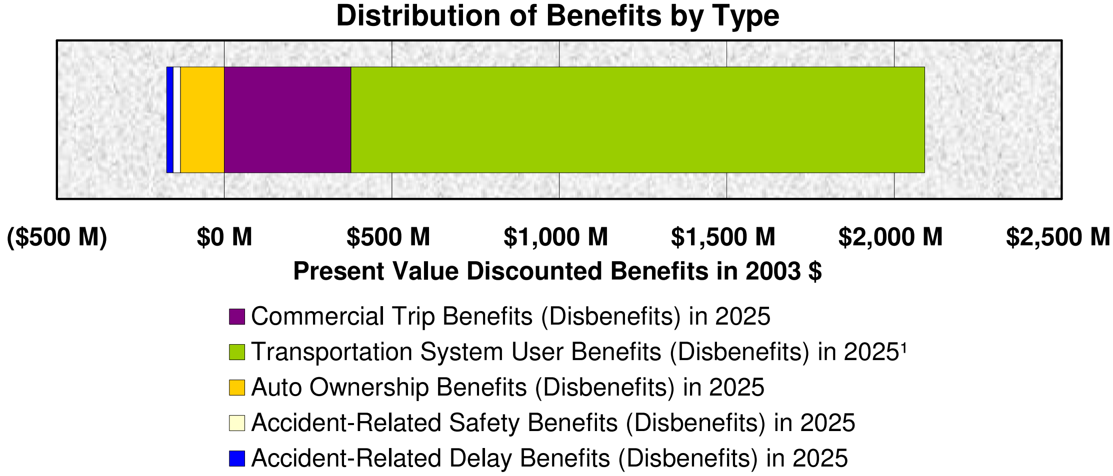

Table 10 — Sample Benefit-Cost Evaluation for the Low End of the Ranges

Congestion Relief Analysis Study — Annual Benefits and Costs for the Benefit-Cost Analysis

Region: Puget Sound ***Scenario:*** Highway Emphasis Mixed Scenario **Low End of Ranges**

Benefits of Scenario

	Benefit Type	***Daily Benefits (2003 $)***		***Annual Benefits (Millions of 2003 $)***	***Disc PV of Annual Benefits (Millions of 2003 $)***
1	Auto User Benefits (Net Travel Time & Out of Pocket Cost Savings)	$8,647,748		$2,594.3 M	$1,217.1 M
2	Transit User Benefits (Net Travel Time & Out of Pocket Cost Savings)	$1,084,607		$325.4 M	$152.7 M
3	Commercial Trip User Benefits (Net Travel Time & Operating Cost Savings)	$2,148,528		$644.6 M	$302.4 M
4	Accident-Related Congestion Delay Time Savings	($105,376)		($31.6 M)	($14.8 M)
5	Accident-Related Loss Reduction / Safety Benefits	($124,730)		($37.4 M)	($17.6 M)
6	Auto Ownership Cost Savings	($746,135)		($223.8 M)	($105.0 M)
Total Benefits		$10,904,642		$3,271.4 M	**$1,534.8 M**

System-wide Annual Auto VMT: 34,198,860,000 Undisc. Benefits per VMT $0.076 PV Benefits per VMT: $0.036

Implementation Costs for Scenario

	Capital Element	***Cost (Millions of 2003 $)***	***Cost (Billions of 2003 $)***	***Useful Life (Years)***	***Construction Duration***	***Construction Midpoint***	***Construction Start Year***	***Annualized Cost (Millions of 2003 $)***	***Disc PV of Annualized Cost (Millions of 2003 $)***
1	Highway Infrastructure	$65,479 M	$65.48 B	50 Years	11 Years	2019	2014	$3,431.6 M	$1,979.0 M
2	Transit Infrastructure	$7,004 M	$7.00 B	30 Years	5 Years	2022	2020	$422.2 M	$219.6 M
3	Transit Vehicles	$2,804 M	$2.80 B	30 Years	4 Years	2023	2021	$163.3 M	$82.1 M
4	Transit Vehicles	$337 M	$0.34 B	12 Years	2 Years	2024	2023	$36.1 M	$25.3 M
5	Transit Infrastructure	$86 M	$0.09 B	20 Years	1 Years	2024	2024	$6.2 M	$3.0 M
6	Transit Infrastructure	$83 M	$0.08 B	50 Years	1 Years	2024	2024	$3.6 M	$1.8 M
7	Transit Vehicles	$182 M	$0.18 B	30 Years	2 Years	2024	2023	$10.3 M	$5.0 M
8	Right-of-Way	$15 M	$0.02 B	50 Years	1 Years	2024	2024	$0.7 M	$0.3 M
9	Environmental	$30 M	$0.03 B	50 Years	1 Years	2024	2024	$1.3 M	$0.7 M
10									
Totals		**$76,021 M**	**$76.02 B**		**11 Years**	**2019***		**$4,075.5 M**	**$2,316.8 M**

Note: Last year of construction = 2024 * Weighted average construction midpoint for purposes of calculating capital cost present value.

System-wide Annual Auto VMT: 34,198,860,000 Undisc. Capital Cost per VMT $0.119 PV Capital Cost per VMT: $0.068

Annual O&M Costs for Scenario

	O&M Element		***Revenue Offset Percentage (Transit Farebox)***	***Gross Annual Cost (Millions of 2003 $)***	***Net Annual Cost (Millions of 2003 $)***	***Disc PV of Net Annual Cost (Millions of 2003 $)***
1	Highway	Yearly O&M costs 2003 dollars		$90.0 M	$90.0 M	$42.2 M
2	Transit			$390.0 M	$390.0 M	$183.0 M
3	Transit	Passenger Ferries		$30.0 M	$30.0 M	$14.1 M
4						
5						
Totals				$510.0 M	$510.0 M	**$239.3 M**

Table 11 — Sample Table of Annualized Benefit and Cost Ranges in Discounted Present Values

Scenario	*Discounted Present Values*					
	2025 Annual Benefits Range			*Annualized Capital + O&M Costs Range*		
	Low End	*Expected Value*	*High End*	*Low End*	*Expected Value*	*High End*
Highway Focus	$1.5 B	**$1.8 B**	$2.2 B	$2.5 B	**$2.8 B**	$3.7 B
Transit Focus	$0.5 B	**$0.6 B**	$0.7 B	$1.2 B	**$1.2 B**	$1.5 B
Pricing Focus	$0.7 B	**$0.9 B**	$1.1 B	$0.3 B	**$0.3 B**	$0.3 B
Mixed – Highway & Transit Intensive	$1.6 B	**$2.0 B**	$2.4 B	$2.8 B	**$3.0 B**	$3.8 B
Mixed – Highway Emphasis	$1.5 B	**$1.9 B**	$2.3 B	$2.6 B	**$2.7 B**	$3.5 B
Mixed – Transit Emphasis	$1.0 B	**$1.3 B**	$1.6 B	$2.3 B	**$2.4 B**	$3.1 B
Mixed – Transit Emphasis + Pricing	$1.7 B	**$2.1 B**	$2.5 B	$2.4 B	**$2.5 B**	$3.3 B

Note: Benefits and costs are expressed as ranges around future expected values, expressed in 2003 dollars inclusive of present value discounting.